GB2296696

Publication Title:

Deformable aerofoil

Abstract:

Abstract not available for GB2296696
Abstract of corresponding document: DE4446031

An aerofoil 2, at least one section of the wing shell 4, on which local bulges 8 may be produced by deformation and which extends over a substantial part of the span of the wing, is provided as means to reduce ultrasonic shocks in the aft portion of the upper wing shell. The deforrnable section of the wing skin 4 is made of a fibre composite, the fibres of which are aligned orthotropically so that the wing skin has a low flexural strength in the direction of the wing chord and a high flexural strength in the direction of the span of the wing. Deformation may be eflected by a spannise arrays of lacks (26) (fig.2), bimorph elements, piezoceramic drives or memory elements.

Data supplied from the esp@cenet database - Worldwide

Courtesy of http://v3.espacenet.com

This Patent PDF Generated by Patent Fetcher(TM), a service of Stroke of Color, Inc.

(12) UK Patent Application (19) GB (11) 2 296 696 (13) A

(43) Date of A Publication 10.07.1996

(21) Application No 9526236.6

(22) Date of Filing 21.12.1995

(30) Priority Data
(31) 4446031 (32) 23.12.1994 (33) DE

(71) Applicant(s)
Deutsche Forschungsanstalt Für Luft- und Raumfahrt e.V.

(Incorporated in the Federal Republic of Germany)

Linder Höhe, D-51147 Köln,
Federal Republic of Germany

(72) Inventor(s)
Rainer Schütze
Elmar Breitbach
Hans-Christian Goetting

(51) INT CL^{6}
B64C 3/38 23/00

(52) UK CL (Edition O)
B7W WWE
F2R RP

(56) Documents Cited
WO 94/26588 A1 WO 93/02915 A1 DE 004007694 A1
US 4232844 A

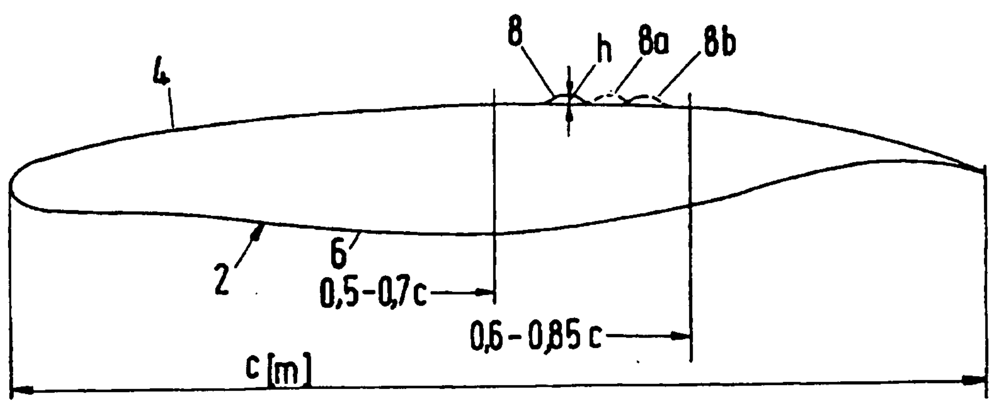
(58) Field of Search
UK CL (Edition O) B7W WWE, F2R RD RF RP
INT CL^{6} B64C 3/00 21/00 23/00
ONLINE WPI

(74) Agent and/or Address for Service
Williams,Powell & Associates
34 Tavistock Street, LONDON, WC2E 7PB,
United Kingdom

(54) **Deformable aerofoil**

(57) An aerofoil 2, at least one section of the wing shell 4, on which local bulges 8 may be produced by deformation and which extends over a substantial part of the span of the wing, is provided as means to reduce ultrasonic shocks in the aft portion of the upper wing shell. The deformable section of the wing skin 4 is made of a fibre composite, the fibres of which are aligned orthotropically so that the wing skin has a low flexural strength in the direction of the wing chord and a high flexural strength in the direction of the span of the wing. Deformation may be effected by a spannise arrays of jacks (26) (fig.2), bimorph elements, piezoceramic drives or memory elements.

Fig. 1



GB 2 296 696 A

Fig. 1

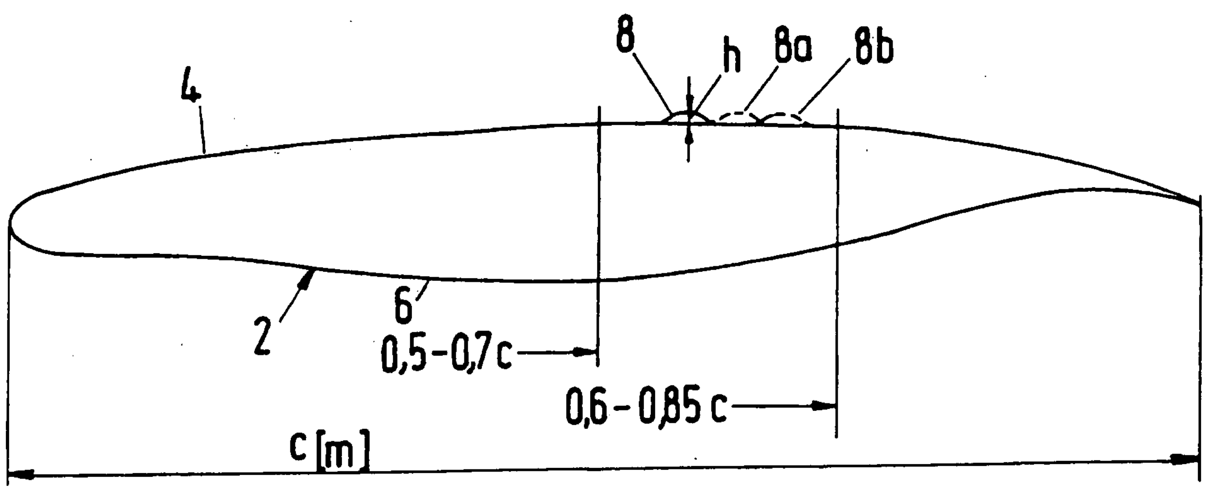


Fig. 2

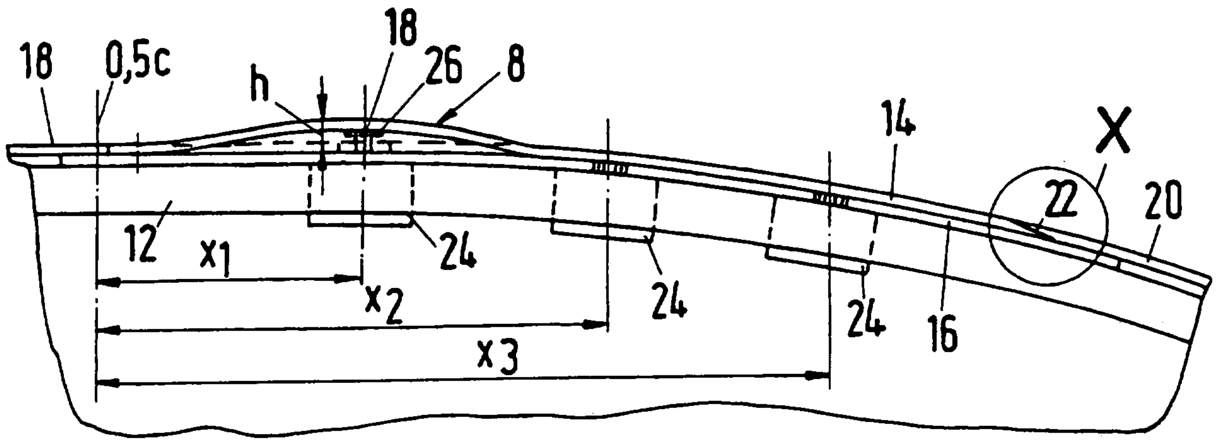


Fig. 3

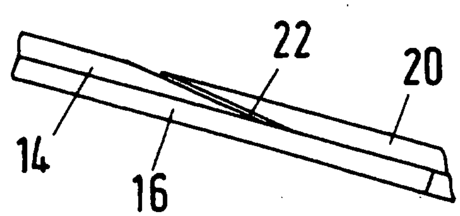
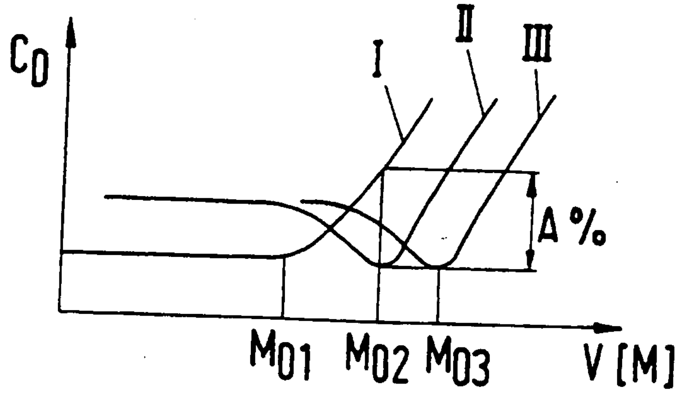


Fig. 4



2296696

AEROFOIL

The invention relates to an aerofoil, in which at least one section of the wing shell, on which local bulges may be produced by deformation and which extends over a substantial portion of the span of the wing, is provided as means to reduce ultrasonic shocks in the aft portion of the upper wing shell.

In the transonic speed range, ultrasonic shocks result in the aft portion of the aerofoil profile which occur in dependence on the flow velocity on the upper side of the aerofoil in various chordal zones of the aerofoil and lead to an increase in the aerodynamic resistance, and thus have a substantial influence on the economy of operation of the aircraft.

It is known to render the profile of the upper wing shell in the aft portion of the aerofoil variable for aerofoils for operation in the transonic speed range (DE 40 07 694 C2), that is by varying the profile thickness in the aft portion of the aerofoil in such a way as to permit alternation between a profile with low drag with large profile thickness in the aft portion of the aerofoil and a profile with high lift with smaller profile thickness in the aft portion of the aerofoil. In this case, two contour elements extending essentially over the span of the wing and hinged to one another are provided in the upper wing shell as means for varying the profile thickness in the aft portion of the aerofoil, the front contour element being hinged to the aerofoil structure in the region of the transition point for flow with high lift in such a way that the hinge gap is completely closed in the position of the contour elements for low drag, and the connecting element between the two contour elements is arranged in the region of the transition point for flow with low drag.

An aerofoil with supercritical form is known from WO 93/02915 in which the aerofoil skin is made of an elastically distensible aluminium-based metal alloy, in particular an aluminium-copper alloy designated AA2124. Jacks and cams are provided for operation.

According to an aspect of the present invention, there is provided an aerofoil in which at least one section of the wing shell on which local bulges may be produced by deformation and which extends over a substantial part of the span of the wing, is provided as means to reduce ultrasonic shocks in the aft portion of the upper wing shell, wherein the deformable section of the wing skin is made of a fibre composite, the fibres of which are aligned orthotropically so that the wing skin has a low flexural strength in the direction of the wing chord and a high flexural strength in the direction of the span of the wing.

It is possible with the invention to construct the aerofoil skin in aerofoils of the said type in such a way as to enable the forces of operation to be reduced and deformation to be reproduced.

An embodiment of the present invention is illustrated in the drawing and is described below by way of example in detail on the basis of the drawing, in which

Figure 1 shows a transonic aerofoil profile in cross-section with a section constructed to reduce the effect of ultrasonic shocks;

Figure 2 shows the region of an embodiment of upper wing shell in cross-section with details of the profile;

Figure 3 shows a detail at point X in Figure 2;

Figure 4 shows a diagram with drag coefficients of an embodiment of aerofoil plotted against the speed.

Figure 1 shows a schematic representation of a cross-section through an aerofoil 2 with transonic profile 2 represented by its upper aerofoil shell 4 and its lower aerofoil shell 6. The aerofoil has a chord c. A region in which ultrasonic shocks occur is located in the upper aerofoil shell 4. This region is dependent on the profile and generally lies between 0.5c - beginning and 0.6-0.85c - end. Means spaced from one another in the direction of the wing chord are provided in this region, and these means permit local bulges to be produced on the upper surface of the profile of the upper wing shell by an elevation h. In Figure 1 three regions lying one behind the other at a distance a are shown as an example in which such bulges 8, 8a and 8b can be produced. For this, means are arranged in the direction of the wing chord with which such bulges can be adjusted in dependence on the flow velocity in various profile chordal zones, as is described below with reference to Figure 2.

The effect of the bulging is shown in the diagram in Figure 4. The curve I shows the drag coefficient C_D with a profile according to Figure 1 without bulging of the profile upper surface. It is assumed here that a transition of the laminar flow occurs with a flow velocity M_{01} at about 0.5 c and thus to an ultrasonic shock at this point. The aerodynamic drag coefficient increases steeply from M_{01}, as is shown by curve I.

A local bulge h of the profile contour on the upper side of the profile at the point where the ultrasonic shock occurs at higher flow velocities results in a reduction in shock

and thus to a shift of the increase in drag to a higher flow velocity (curve II). The minimum drag is then located at the approach flow velocity M_{02} ($>M_{01}$).

If a local bulge h of the profile contour is generated at one point 8b which lies still further aft than the previously specified point 8a, a drag curve according to curve III is formed. However, the minimum drag M_{03} is shifted to a higher approach flow velocity.

The drag saving achieved by curve II at flow velocity M_{02} in comparison to curve I (profile without bulging) amounts to approximately A [%]. An even greater gain is achieved in comparison with curve I at higher approach flow velocities and with bulges located correspondingly further aft.

As a result of the speed-dependent bulging of the profile contour in various profile chords, the aircraft can thus be operated over a wider speed range with an economically more favourable drag coefficient which corresponds in Figure 4 to the regions of curves I-III marked by dotted underlining.

It is of course also possible to provide more than three regions lying one behind the other in the wing chord in which corresponding bulges can be produced.

A bulge elevation amounting to about 0.2 % of the wing chord, i.e. of 10 mm with a wing chord of 5 m, is to be provided for bulge h.

The section of the upper wing shell on which a bulge may be produced is to be provided for the regions of the aerofoil critical to flow. This is to be generally provided for the predominant region of the span of the wing. The bulged sections then extend in a linear shape like a kind of wave

crest in the respective profile chordal zone over the span of the wing.

Figure 2 shows a schematic representation of the bulge produced on the wing skin of the upper aerofoil shell. The aerofoil shell is reinforced in the usual manner by stringers and ribs on which the rigid wing skin of the upper wing shells 4 absorbing torsional forces and moments is fastened. These reinforcements are shown schematically in Figure 2 by ribs 12.

A flexible wing skin 14 is arranged on the rigid wing skin of the upper wing shell of the aerofoil 2 in the regions in which a bulge may be produced on the profile of the upper wing shell. The rigid wing skin 16 of the aerofoil is sunken in this region to such an extent that the flexible wing skin 14 forms a continuation of the rigid wing skin 18, 20 on the sunken region 16 of the rigid wing skin. In the shown embodiment, the flexible wing skin 14 is fixed in the zone 0.5c to the sunken rigid wing skin 16 lying below it, e.g. bolted, riveted or sewn thereto. In the remaining zone the flexible wing skin 14 lies on the rigid wing skin 16 so as to be displaceable in the direction of the profile chord. At its rear end, the flexible wing skin 14 engages under the rigid wing skin 20 in the aft region of the wing with a tapered overlap 22.

In the embodiment according to Figure 2, the flexible wing skin 14 is shown with possible bulging in three profile chordal zones 0.5c + x_1 or x_2 or x_3. The distances x_1, x_2, x_3 correspond to the flow velocities at which a respective minimum in the drag coefficient C_D should be attained. To produce the bulging, operating elements 24 are provided in the embodiment which may be fastened, for example, on the rigid aerofoil skin 16 or on the stringers or ribs 12 or

also on another structural element of the aerofoil.

In the embodiment jacks 26 are provided as adjustable elements which may be driven, for example, by conventional electromechanical spindle drives, hydraulic slide rod drives or by new types of actuators, e.g. bimorph elements, piezoceramics or NiTi form memory alloys. A plurality of such jacks are spaced from one another in the direction of the span of the wing. The jacks 26 are shown here with a head 28 via which the jacks are connected positively to the flexible skin, i.e. in such a manner as to permit a relative movement in the direction of the profile chord between the drive element and the head 28 of the jack 26 and thus the flexible skin 14. This may be achieved, for example, with an intermediate member hinged on both sides.

By operation of all the respectively adjacent jacks 26, the flexible skin 14 is lifted and a bulge h of the profile shaped like a wave crest is formed in the direction of the span. As stated above, ultrasonic shocks are reduced by this bulge. As a result, the profile drag coefficient C_D of the aerofoil is kept low. The various (e.g. three) rows of operating elements are operated in dependence on the respective air flow velocity on the upper wing shell and the drag coefficient is thus optimised in the respective speed range.

As specified above, the jacks 26 can be provided with individual drives. However, they may also be in positive engagement with operating means arranged transversely to the profile chord, i.e. in the direction of the span of the wing, such as displaceable operating rails or drive spindles. It is important that when no bulging has occurred, the flexible skin can be held firmly in abutment on the rigid wing skin lying underneath by the drive device.

Although the flexible skin does not absorb any transverse forces and bending moments from the wing stress, it is stressed by the drag forces acting vertically on the flexible skin which must be transferred to the structure of the aerofoil.

The operating elements can be enclosed in a control circuit with sensors which measure the flow velocity in situ, in which case the operating elements allocated to respectively pre-set values are then made effective. However, empirically determined adjustment values can be allocated to the operating elements in dependence on the relative speed of the aircraft in relation to the air.

In a particularly expedient embodiment, the material used for the flexible skin is a fibrous composite, the fibres of which are aligned orthotropically so that the flexible skin has a low flexural strength in the direction of the wing chord and a high flexural strength in the direction of the span of the wing. High-tensile fibres, e.g. carbon fibres, may preferably be used as fibres here, however, fibres made of silicon carbide and similar may also be used. The high flexural strength in the direction of the span of the wing enables the operating elements to be arranged at greater distances from one another, and thus allows the number of operating elements per unit length of the span of the wing to be kept small. The use of fibre composites also enables the coupling or connecting elements between the operating elements and the wing skin to be attached by sewing, e.g. with C fibre rovings. Seams with C fibre rovings can also be used to fasten the flexible skin at its front end. The seam material in this case is preferably threaded in dry and is subsequently embedded into a rigid matrix by impregnating it with a synthetic resin.

An aerofoil with means for varying the profile in the aft portion of the upper wing shell is also proposed. On the profile upper side of the upper wing shell in the zone larger than 50% of the wing chord, in which ultrasonic shocks occur, at least one section of the wing skin is provided, on which local bulges may be produced upwards beyond the profile upper side by deformation and which extends over a substantial part of the span of the wing. The section on which bulging may occur has a flexible skin which lies on a rigid section of the wing skin. Operating means are spaced in the direction of the wing chord to permit local bulging of the wing skin to be formed in dependence on the flow velocity. The deformable section of the wing skin is made of a fibre composite, the fibres of which are aligned orthotropically so that the wing skin has a low flexural strength in the direction of the wing chord and a high flexural strength in the direction of the span of the wing.

The disclosures in German patent application P4446031.7, from which this application claims priority, and in the abstract accompanying this application are incorporated herein by reference.

Claims:

1. An aerofoil, in which at least one section of the wing shell on which local bulges may be produced by deformation and which extends over a substantial part of the span of the wing, is provided as means to reduce ultrasonic shocks in the aft portion of the upper wing shell, wherein the deformable section of the wing skin is made of a fibre composite, the fibres of which are aligned orthotropically so that the wing skin has a low flexural strength in the direction of the wing chord and a high flexural strength in the direction of the span of the wing.

2. An aerofoil according to Claim 1, wherein a rigid section of the wing skin is provided below the deformable section as support for said deformable section.

3. An aerofoil according to Claim 1 or 2, including operating means spaced in the direction of the wing chord to enable local bulges in the wing skin to be formed in dependence on the flow velocity, and wherein the fastening means are positively connected to the underside of the deformable section of the wing skin.

4. An aerofoil according to Claim 1, wherein the deformable section of the wing skin is fixed at its front edge to the rigid skin of the wing shell, and at its rear edge engages to slide under the rigid skin of the wing with a tapered overlap.

5. An aerofoil according to Claim 3, wherein at least two jacks adjustable essentially vertically to the profile upper surface and spaced in rows in the wing chord are

provided which are spaced from one another in the span of the wing.

6. An aerofoil according to Claim 5, wherein the jacks operable electromechanically by pistons of a hydraulic, pneumatic drive element are connected via a hinged intermediate member.

7. An aerofoil according to Claim 5, wherein the jacks are connected to an electromechanically operated spindle or slide rod drive via a hinged intermediate member.

8. An aerofoil according to Claim 5, wherein the jacks are arranged in engagement with an operating rod adjustable in the direction of the span of the wing.

9. An aerofoil according to Claim 3, wherein bimorph elements are provided as drives.

10. An aerofoil according to Claim 3, wherein piezoceramics are provided as drives.

11. An aerofoil according to Claim 3, wherein NiTi form memory elements are provided as drives.

12. An aerofoil according to any preceding claim, wherein the bulges amount to about 0.2% of the wing chord.

13. An aerofoil substantially as hereinbefore described with reference to and as illustrated in the accompanying drawing.

Application No: GB 9526236.6
Claims searched: 1-13

Examiner: C B VOSPER
Date of search: 20 March 1996

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:
UK Cl (Ed.O): B7W(WWE); F2R(RD,RF,RP)
Int Cl (Ed.6): B64C 3/00,21/00,23/00
Other: ONLINE WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	WO94/26588A1	GRUMMAN (fig.4; page 17, line 18 et seq.)	1
Y	WO93/02915A1	DEFENCE (whole document)	1
Y	US4232844	SOBEY/DEFENCE (col.2, lines 9 to 17 - shows determination of bending stiffness between span wise and chordwise directions by means of fibre alignment))	1
A	DE4007694A1	DEUTSCHE- (whole document)	1

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
		E	Patent document published on or after, but with priority date earlier than, the filing date of this application.
&	Member of the same patent family		